ABSTRACT

Title of thesis: A COMPARISON OF SEMANTIC CONVERGENCE IN YOUNGER AND OLDER HINDI-ENGLISH BILINGUAL SPEAKERS

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Semantic convergence offers support that the bilingual language system comprises a merging of two languages rather than the sum of two languages. This phenomenon has been studied in multiple language areas and in young children and adults. However, it is unclear how semantic convergence compares across grammatical class and across the lifespan. In this study, Hindi-English aging and adult bilinguals completed a word association task in response to verb and noun stimuli. Results showed that younger adult bilinguals experience more semantic convergence compared to older adult bilinguals, and that semantic convergence is greater for nouns compared to verbs. The results for word class are discussed in the context of the *retrieval induced reconsolidation hypothesis, cross-language interference hypothesis,* and *weaker links hypothesis*. The implications for aging are contextualized within the current research on aging and bilingualism.

Keywords: bilingual, word association, semantic convergence, aging

A COMPARISON OF SEMANTIC CONVERGENCE IN YOUNGER AND OLDER HINDI-ENGLISH BILI1NGUAL SPEAKERS

by

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Table of Contents

Table of Contents i
List of Tables ii
List of Figures iii
Introduction 1
Literature Review 2
Research Questions and Hypotheses 18
Methods 20
Results 28
Discussion 33
Appendix A 46
Appendix B 46
References 49

List of Tables

Table 1. Statistical comparisons between age and word class categories..... 32
Table 2. Example noun and verb responses from one younger participant and one older participant 35

List of Figures

Figure 1. Mean number of Hindi Responses. 28
Figure 2. Mean number of English responses. 29
Figure 3. Mean number of language intrusions in the word association task, generated over 40 seconds. 30
Figure 4. The mean number of translation pairs within the first four generated words. .. 31

Introduction

The manner in which bilinguals organize language through semantics, phonology, morphosyntax, and even gesture has been a source of interest in many studies (Peña, Bedore, & Kester, 2015; Sumiya & Healy, 2004; Krause, Bosch, & Clahsen, 2015; Nicoladis, Pika, & Marentette, 2009). Across topics of study (semantics, phonology, etc.), studies have sought to define and explain bilingual language performance relative to monolingual performance. Are bilingual language speakers essentially two monolinguals combined in one person, meaning that bilinguals have two separate language systems? Or is there a degree of overlap in the two language systems of bilinguals indicative of a merged language system? There is increasing evidence that bilinguals have a merged language system across several language domains that is not merely the sum of two individual language systems in phonology (Flege and MacKay, 2004; Golestani & Zatorre, 2009) and lexicon (Ameel, Malt, and Storms, 2015; Aferink & Gullberg, 2014). One phenomenon that demonstrates this is language convergence.

Language convergence is a well-documented phenomenon in bilingual populations in which the L1 and L2 language systems exert a mutual influence over one another (Brown, 2015; Ameel, Malt, Storms, & Van Assche, 2009; Alferink & Gullberg, 2014). While past studies have documented evidence of convergence in multiple language areas, the literature has focused primarily the impact of semantic convergence on the language system of children and young adults (30 years or younger) and in a single domain of language (object naming, verb semantics, phonemes, etc.). It is still not clearly understood if the same degree of convergence exists across grammatical class (e.g., nouns vs. verbs) or how aging interacts with convergence. This study aims to address

these gaps in knowledge. In the following sections, bilingualism will be briefly reviewed; this will be followed by a review of bilingualism and its relationship with semantic convergence, grammatical category, and aging.

Literature Review

Bilingualism

Bilingualism has been a topic of interest for decades, and there is significant interest in describing how bilinguals' first (L1) and second languages (L2) interact with each another across multiple dimensions including language domains, time of L2 acquisition, and age. Bilingual performance has been examined in multiple language domains, including, but not limited to phonological activation (Jouravlev, Lupker, & Jared, 2014; Jared, Cormier, Levy, &Wade-Woolley, 2012; Sumiya & Healy, 2004), syntactic processing and awareness (Saur et al., 2009; Shin & Christianson, 2009), and lexical access (Libben & Titone 2009; Marian & Spivey, 2003). In addition, there has been work exploring the impact of age of L2 language acquisition on bilingual language systems, particularly L2 proficiency (Mueller, Gathercole, & Abdelmatloub Moawad, 2010; Alarcón, I., 2011; Foote, 2011) and neurological mappings of early and late bilingualism (Consonni et al., 2013; Pratt, Abbasi, Bleich, Mittelman, & Starr, 2013; Yan, Zhang, Xu, Chen, & Wang, 2016). Age-related studies on bilingualism have examined how bilingualism impacts early development or language and/or executive

control in aging populations (Brown, 2015; Davidson & Tell, 2005; Jared, Cormier, Levy, & Wade-Woolley, 2012; Gold, 2015; Gollan, Sandoval, & Salmon, 2011).

Studies have looked at linear interactions between L1 and L2 (i.e., the influence of L1 on L2 and vice versa). The influence of bilingual speakers' L1 on their L2, particularly during the process of acquisition is a well-documented phenomenon and has formed much of the initial research into the bilingual language system (Elston-Güttler, Paulmann, & Kotz, 2005; Manchón & De Larios, 2007). Alternatively, several studies have explored the impact of the L2 on L1, suggesting that L2 can cause L1 attrition (Chamorro, Sorace, & Sturt, 2016; Schmid, 2010), that L2 can have a facilitative effect on a bilingual's L1 (Runnqvist & Costa, 2012), or that L2 can have a unidirectional effect that is neither facilitative nor inhibitory (Bylund & Jarvis, 2011). Although these studies vary in the variables addressed, studies on bilingualism consistently reach two conclusions: 1. the bilingual language patterns are significantly different from those of monolingual speakers and 2. there is a cross-linguistic impact and/or interaction between an L1 and L2 that serves as the underlying mechanism for bilingual language patterns (Anderson, Saleemi, & Bialystok, 2017; Davidson, & Tell, 2005; Marian & Spivey, 2003).

Increasingly bilingual studies have focused on a third option of language interaction: the co-activation or convergence of two languages to create a unique bilingual system that does not fully mirror an L1 and an L2 (Brown, 2015; Ameel et al., 2009; Alferink & Gullberg, 2014). These studies suggest that the bilingual language system is created by the mutual interaction of an L1 and L2.

Semantic convergence

Semantic convergence is a phenomenon in bilingual populations where the language systems of both L1 and L2 mutually influence each other with respect to semantics, syntax, phonology, etc. to produce a unique bilingual system that is distinct from the language systems of monolinguals in either L1 or L2 (Aferink & Gullberg, 2014). The term "semantic convergence" is associated and often used interchangeably with other terms like bidirectional transfer and language convergence (Malt, Li, Pavlenko, Zhu, & Ameel, 2015; Ameel, Malt, Storms, & Van Assche, 2009). For the purpose of this study, semantic convergence is defined as a unique language system created by the interaction of an L1 and L2 (Storms, Ameel, & Malt, 2015). However, semantic convergence is defined differently in some studies. In a study conducted by Sheng, Bedore, Peña, and Taliancich-Klinger (2013), semantic convergence is described in the context of bilingual children and primary language impairment and is defined as the process of learning how to use words in a way that accurately reflects the words' usage by speakers from the same community. However, it should be noted that more often the definition of semantic convergence aligns with the definition presented in this study (White, Malt, & Storms, 2016; Aferink & Gullberg, 2014, Ameel, Storms, Malt, & Sloman, 2005; Ameel et al., 2009). Semantic convergence has been observed in a variety of language tasks, including discourse and object naming; in a variety of bilingual groups, including French-English bilinguals, Dutch-French, and Mandarin-English bilinguals; and in both early and late bilinguals (Brown & Gullberg, 2008; Pavlenko & Jarvis, 2002; Ameel et al. 2005; Ameel et al., 2009).

Semantic convergence: Concrete nouns

There have been multiple studies on semantic convergence of concrete object naming conducted by Malt, Ameel, Storms and colleagues (Ameel, Storms, Malt, & Sloman, 2005; Ameel, Malt, Storms, & Van Assche, 2009). In this series of studies, French-Dutch and Mandarin-English bilinguals completed a series of tasks designed to evaluate semantic convergence, specifically convergence for category centers and boundaries in both L1 and L2 (Ameel et al, 2005; Ameel et al., 2009; White, Malt, & Storms, 2016). In these studies, categories refer to the group of exemplars that are associated with one another under a single label (e.g., bottle vs. jar). Category centers are thought to be strongly determined by high-frequency words (i.e., words generated frequently as exemplars of a category), and category boundaries are considered to be determined by low-frequency exemplars situated at the border where they are neither one or another category and often share fewer characteristics in common with other exemplars (Ameel et al., 2009). In these studies, bilingual participants were presented with pictures of container exemplars and asked to name them in both languages. The naming responses were compared to French and Dutch monolingual counterparts along two characteristic dimensions (i.e., category centers and boundaries). The results showed that bilingual category centers are closer to one another compared to those of monolingual language systems. That is, the category center for the prototypical jar in French for bilingual participants was closer to the category center of the prototypical jar in Dutch for bilinguals rather than to the monolingual French category center for the prototypical jar. This is because bilinguals are unable to keep categories as separate as their monolingual counterparts. Further, category boundaries were less complex because

bilinguals did not differentiate categories along as many dimensions as monolinguals. Ameel and colleagues suggest that the differences between monolinguals and bilinguals in category centers and boundaries show that bilingual language systems are subject to semantic convergence (Ameel et al., 2005; 2009).

These studies by Ameel and colleagues provide compelling evidence that both centers and boundaries for concrete object categories are subject to semantic convergence in the bilingual language system. Although the underlying mechanism for semantic convergence is unknown, Ameel and colleagues propose two potential mechanisms that act together to explain naming patterns in bilinguals: a *weaker links hypothesis* and a *retrieval induced reconsolidation hypothesis*. The *weaker links hypothesis* suggests that generally bilingual language systems are more susceptible to L1 or L2 influence because compared to monolinguals, the bilingual language system has weaker mappings onto referents in each language. Bilinguals have weaker mappings because they have less exposure to individual lexical representations in both languages compared to monolinguals in either language. These weaker mappings of lexical representations makes the language system of bilinguals more vulnerable to change via the retrieval induced reconsolidation hypothesis. The retrieval induced reconsolidation hypothesis suggests that when a bilingual retrieves a lexical entry from his/her L2, the use of the L2 representation reactivates the L1 correlate or analog, which creates an opportunity for influence and change of the L1 until the bilingual's L1 and L2 usage begins to share features that are found in a monolingual language system (Ameel et al, 2005; 2009). Ameel and colleagues (2009) applied the concept of retrieval induced reconsolidation based on a study by Wolff and Ventura (2009) that examined semantic differences in

Russian-English bilingual descriptions of causal events in Russian compared to Russian monolinguals. The study by Wolf and Ventura (2009) suggests that the semantic differences of bilingual and monolingual descriptions may be attributed to word use and constructions of the bilinguals' L2 (i.e., English). The phenomenon of retrieval induced reconsolidation suggests that activation of mutual L1-L2 analogs can make a consolidated memory for that representation temporary labile and vulnerable to modification, and therefore can shift the semantic parameters for a particular language element (Wolff & Ventura, 2009).

While these studies offer compelling evidence for semantic convergence in concrete noun representations (i.e., objects), it is unclear how semantic convergence interacts with other types of word categories such as abstract nouns or verbs, and the picture naming task outlined in these studies does not allow for grammatical class comparisons (e.g., nouns and verbs). Specifically, there are not enough exemplars for any given verb to allow for analysis of semantic convergence through category centers and boundaries.

Convergence: Verbs and syntactic structures

Two studies have examined the phenomenon of semantic convergence in verbs and use of syntax. One study by Aferink and Gullberg (2014) examined the degree of convergence in use of placement verbs by French-Dutch bilingual speakers. In this study, French and Dutch monolinguals and French-Dutch bilinguals were asked to describe pictures of an object and its placement to another person in a barrier drawing task. French does not require a placement distinction, but Dutch does make a semi-obligatory

distinction of verb choice based on placement. If bilinguals used verb choices in French and Dutch similar to those used by their monolingual counterparts, then semantic convergence would not occur for placement verbs. However, Aferink and Gullberg found that when speaking Dutch, bilingual participants did not make the semi-obligatory distinction in verb choice, unlike the Dutch monolingual participants, indicating that the bilinguals had adopted a verb choice pattern more similar to French. In another study by Fredsted (2008), German-Danish bilinguals and trilinguals participated in free discourse tasks, and the audio data were analyzed for predicate-argument structure in both languages. It was found that German-Danish bilinguals and trilinguals used Danish syntactic structures and conventions when speaking in German. In both studies, some participants were simultaneous bilinguals (i.e., they learned languages simultaneously) and some participants were early sequential bilinguals (i.e., they learned their L2 before age 3 but not at the same time as their L1). All participants had comparable proficiency in both L1 and L2 and functionally used both languages in daily life (Aferink & Gullberg, 2014; Fredsted, 2008).

When compared to the studies by Ameel, Malt, and Storms and colleagues, these studies show that semantic convergence is not only limited to a specific grammatical class but also occurs in verb and syntactic use. Both studies were structured on tasks that allowed for sentence production (e.g., picture description, discourse/conversations tasks), which is sufficient for examining convergence in verbs and syntax alone. However, like studies on convergence in object naming, these tasks do not allow for cross-grammatical category comparisons. Therefore, while it is known that convergence occurs for both

nouns and verbs in bilingual language systems, it is unknown if there is more convergence in one grammatical class over the other.

Bilingualism and grammatical category

There has been some research into how monolingual language systems interact with grammatical category. The difference between verbs and nouns has been examined in the context of typical monolingual language acquisition. Gentner (1982) notes that across all languages, there are consistent distinctions made between concepts represented by nouns and verbs and explores two possible underlying hypotheses: the *natural partitions hypothesis* and the *linguistic relativity hypothesis*. The *natural partitions hypothesis* attributes the linguistic distinction made between verbs and nouns to another perceptual distinction between concrete concepts (i.e., objects and persons) and predicative concepts (i.e., activity, state, causal relations). The *linguistic relativity hypothesis* states that language dictates perceptual distinctions between verb and noun concepts. Through analysis of developmental language learning patterns in six languages that differ in word order and noun/verb morphological complexity, Gentner provides a compelling argument that linguistic distinctions between nouns and verbs are based on the natural partitions hypothesis, i.e., verb and noun concepts fall along perceptual differences.

It is a well-documented phenomenon that bilingual speakers perform worse on word production tasks in comparison to monolingual speakers, indicative of a bilingual disadvantage in word retrieval (Sandoval, Gollan, Ferreira, & Salmon, 2010; Martin, Alario, & Costa, 2012; Pyers, Gollan, & Emmorey, 2009). The bilingual disadvantage

has been found in a few studies to have less effect on production for verbs compared to nouns (Faroqi-Shah & Milman, 2015; Li, 2017; Klassert, Gagarina, Kauschke, 2014). This area of study is still emerging, and the underlying mechanism behind the differences between verb and noun bilingual disadvantage has not been fully explored., The *cross-language interference hypothesis* suggested by Green (1998) has been used by some authors as a potential account for the smaller verb compared to noun disadvantage (Faroqi-Shah & Milman, 2015; Li, 2017; Van Hell & De Groot, 1998). This hypothesis predicts a relatively smaller verb bilingual disadvantage based on the assumption that bilingual speakers perform language production tasks accurately by inhibiting associated, within-language and cross-language lemmas (e.g., “snow”, “rain” in English and “la pluie”, “la neige” in French), and that nouns have more associated lemmas across languages due to a relatively higher translatability compared to verbs (Faroqi-Shah & Milman, 2015). Assuming that nouns have more associated lemmas across languages, word retrieval of nouns require more inhibition and therefore lead to slower reaction times and less accuracy compared to verbs. This argument of smaller cross-language interference of verbs needs to be further tested.

In addition, there is evidence that conceptual representations in bilingual memory differ based on concreteness and word class. In one study, Van Hell and De Groot (1998) found that in a double word association task, Dutch-English bilingual participants were more likely to generate associated words in both languages that were translations of each other for nouns over verbs and for concrete concepts over abstract concepts. This study suggests that verbs and abstract concepts share fewer common semantic features cross-linguistically than nouns and concrete concepts and that differences in grammatical class

may correlate with degree of abstractness where nouns are overall less abstract compared to verbs. Van Hell and De Groot note that verbs may even have less dense semantic representations compared to nouns possibly because verbs have a greater range of meaning and are more dependent on linguistic context compared to concrete nouns. In addition, this task has advantage over other described tasks because other tasks have been inherently limited to a specific grammatical class such as naming for concrete objects, description tasks for verb choice, whereas a word association task can be applied to both verb and noun concepts (Ameel et al., 2005; Aferink & Gullberg, 2014; Van Hell & De Groot, 1998).

Underlying mechanisms for convergence

It has been suggested that there is more semantic overlap for nouns compared to verbs (Van Hell & De Groot, 1998), which could serve as the underlying mechanism of semantic convergence across grammatical class. Let it be assumed that 1. Nouns have more cross-linguistic semantic features in common (Van Hell & De Groot, 1998), 2. Nouns activate more cross-linguistic lemmas compared to verbs, and 3. Retrieval of a lexical entry in a bilingual's L2 leads to a reactivation of the L1 correlate or analog creating an opportunity for changing the patterns of L1 (i.e., retrieval induced consolidation) following the hypothesis outlined in Ameel et al. (2005). Given these assumptions, it would be expected that nouns, as a grammatical class, would show a greater degree of semantic convergence compared to verbs. It has been suggested that nouns have a greater degree of semantic overlap and are less ambiguous compared to verbs (Van Hell & De Groot, 1998; Prior, MacWhinney, & Kroll, 2007), but in addition,

there is more opportunity for turbulence and change in a bilingual's L1 via retrieval induced consolidation, because when a bilingual speaker accesses an L2 noun entry, the corresponding L1 analog is reactivated in addition to other related cross-linguistic lemmas (via the *cross-language interference hypothesis*).

Alternatively, a similar more commonly cited hypothesis that could explain convergence is Gollan's *weaker links hypothesis*. According to the weaker links hypothesis, the bilingual language system has weaker mappings onto referents in each language compared to monolinguals. Bilinguals have weaker mappings because they encounter exemplars in each language less frequently than those of monolinguals in either language (Gollan, Montoya, Cera, & Sandoval, 2008). If the weaker links hypothesis has a greater effect on convergence compared to cross-language interference, it would be expected that verbs would have more convergence compared to nouns. Considering nouns and verbs, it has been suggested that nouns have more semantic overlap across languages compared to verbs and that verb processing is impacted by word class ambiguity effects unlike noun processing (i.e., in lexical decision tasks, bilinguals are quicker with reaction times for verbs with word class ambiguity) (Van Hell & De Groot, 1998; Bultena, Dijkstra, & Van Hell, 2013). These findings suggest that verbs experience less cross-language activation due to less semantic overlap and that verb processing is susceptible to within-language overlap indicating that verbs are less fixed in the language system compared to nouns. Therefore, it is possible that in the bilingual system, not only do all words have weaker mappings to referents compared to those of monolinguals (Ameel et al., 2009; Gollan et al., 2008), but verbs have even weaker mappings compared to nouns as shown by a smaller degree cross-language overlap and

more ambiguous word class effects. If this is the case, then verbs would be more susceptible to change compared to nouns and would show a greater degree of semantic convergence. Although the proposed underlying mechanisms are lexical in nature, it has been suggested in previous studies that semantic convergence occurs because of lexical phenomena (for example, see Ameel et al., 2009). The literature seems to suggest that lexical interaction causes the underlying semantic systems to converge and change (Aferink & Gullberg, 2014; Ameel et al., 2009).

To summarize, there are three possible patterns if semantic convergence is compared between nouns and verbs: greater convergence for nouns, which would support the cross-language interference hypothesis, greater convergence for verbs, which would indicate that the weaker link hypothesis has more of a role in convergence, and the same degree of convergence for both grammatical classes, which would indicate that neither cross-language interference nor weaker links impact convergence by grammatical class. Thus, comparing semantic convergence across grammatical categories would further our understanding of how languages are represented in bilinguals.

Bilingualism and aging

Word retrieval decline in older adults has been documented in studies showing that older adult monolinguals are more likely experience tip-of-the tongue moments than younger monolingual counterparts and slowed naming reaction times (Kavé & Knafo-Naom, 2015; Shafto, Stamatakis, Tam, & Tyler, 2010). While healthy older monolingual and bilinguals experience lexical retrieval difficulties and show different lexical production patterns compared to younger adults, there is evidence that the semantic

retrieval process for single item representations remains relatively stable across the lifespan at least in terms of behavioral patterns (Lacombe, Jolicoeur, Grimault, Pineault & Joubert, 2015; Grieder, Crinelli, Koenig, Wahlund, Dierks & Wirth, 2012). One study by Lacombe, Jolicoeur, Grimault, Pineault, & Joubert (2012) showed that while older adults perform similarly to younger adults in semantic decision tasks, older adults have different activation patterns and neurological correlates relative to younger adults. Given that semantic performance remains stable, but activation patterns change across the lifespan, age-related changes to semantic processing do occur, potentially indicative of compensation for an inefficiency in cognitive processing (Lacombe, Jolicoeur, Grimault, Pineault, & Joubert, 2012).

Older bilinguals perform worse on verbal fluency tasks and with reaction times for picture naming compared to age-matched monolinguals, a finding which mirrors the gap found between younger monolinguals and bilinguals. There is some evidence that older bilinguals have different lexical processing patterns relative to younger bilinguals. Specifically, older adult bilinguals have shown decreased efficiency in inhibiting competing lexical items (cross-linguistic interference) in Stroop tasks (Zied et al., 2004). Moreover, older but not younger bilingual performance on executive control tasks correlated with cross-language intrusion errors, indicating that language performance may be impacted by cognitive aging processes (Gollan Sandoval, & Salmon, 2011). Older bilinguals, also show smaller frequency effects than younger bilinguals (Gollan et al., 2008). This finding is consistent with the weaker links hypothesis, because over their lifespan, older bilinguals have used each language more than younger bilinguals, resulting in smaller frequency effects (similar magnitude to monolinguals). Although

there is evidence that aging is generally associated with changes in lexical retrieval, there is still much unknown about how lexical retrieval changes in older adult bilinguals. In addition, it is unclear whether there are differences in grammatical class or semantic convergence as bilinguals age. One potential phenomenon that could influence semantic convergence as bilinguals age is language attrition.

Age-related differences in lexical retrieval and semantic processing may be impacted by L1 attrition in addition to age-related differences in linguistic processing. Many adult bilinguals, particularly in the United States, experience L1 attrition due to increased daily exposure to their L2, which becomes the dominantly used language, and decreased daily exposure to their L1 (Perpinan, 2011). Language attrition, also known as L1 restructuring or L1 rearrangement, is a phenomenon where exposure to an L2 exerts changes, not necessarily language loss, on the L1. Studies of L1 attrition in production tasks show linguistic patterns that shift towards L2 patterns, indicative of L2 influence on L1 patterns. These linguistic patterns occur primarily for use of syntactic judgments that are influenced by pragmatic online decisions in language production (Gurel & Yilmaz, 2011; Sorace & Serratrice, 2009; Perpinan, 2011). Language attrition in aging bilinguals may explain a greater degree of convergence towards L2 features given that older adult bilinguals may experience a greater degree of language attrition the longer they reside in their L2 country.

The current study

Although nouns and verbs in have similar frequency effects in lexical retrieval tasks, nouns have a greater bilingual disadvantage (Li, 2017). Studies examining

differences between nouns and verbs in the bilingual language system have thus far focused primarily on the lexical system and have not been examined through the lens of semantic convergence. Compared to nouns, specifically concrete nouns, verbs are more dependent on linguistic context, have greater range of meaning, and may even have less dense semantic representations compared to nouns (Van Hell & De Groot, 1998). These differences may explain different degrees of convergence across grammatical class. The main goal of the present study is to examine grammatical class differences in semantic convergence and if this changes with age. This will be examined in Hindi-English bilinguals. Hindi-English bilinguals in the United States are typically speakers of Indian English, a variety of English that is learned in the context of Indian languages and culture (Sailaja, 2012). Indian English varies from Standard American English and incorporates features of Indian languages which impact phonology/phonetics, lexicon, morphology, and to a lesser extent, syntax (Sailaja, 2012, D'Souza, 2011). Most notable for the current study, Indian English incorporates Hindi/other Indian language lexical items in English vernacular (e.g., gymkhana for gymnasium).

The current study will measure semantic convergence across grammatical class and age through the double translation word association task outlined in the study by Van Hell and De Groot (1998) and will serve to replicate their findings that nouns differ from verbs in degree of cross-semantic overlap. Bilingual participants will be given verb and noun word stimuli in randomized blocks in one language and asked to generate as many associated words as possible within a given time in the same language. In a second session, they will be asked to complete the same task in the other language. The responses across two sessions will be analyzed for translation pairs, and the number of

translation pairs will be compared across grammatical class and age as a measure of semantic convergence.

A word association task serves to map part of the network of a semantic representation, and the number of translation pairs indicates how much overlap exists in the semantic networks of a single representation in each language. If there is less convergence between the L1 and L2 lexical systems, it would be expected that they share less semantic overlap across representations in their L1 and L2 and therefore have fewer translation pairs. Conversely, if there is more convergence, then more translation pairs would be expected, indicative of a greater degree of semantic overlap. Considering the study by Van Hell and De Groot (1998), it is possible that the number of translation pairs is reflective of the level of abstraction of a word. The study not only found differences in the number of translation pairs between nouns and verbs but also across degrees of concreteness and cognate status. In the current study, the noun and verb stimuli will be controlled for degree of concreteness and cognate status, and so the number of translation pairs should not be confounded by these variables. A word association task using translation pairs is an ideal way to measure semantic convergence because it allows for cross-grammatical class comparison unlike naming or discourse tasks.

Hindi and English comparisons

When comparing linguistic features of nouns and verbs, Hindi and English are similar in many ways. For nouns, both languages encode number (e.g., plurals) and syntactic information (e.g., noun as a subject, possessive, etc.). For verbs and verb tenses, Hindi and English use the same tenses including present simple, present continuous,

present perfect, past simple, past perfect, simple future, and future continuous. However, Hindi speakers show preference for present continuous tenses (e.g., I am speaking) in situations that English monolingual speaker would use simple present (e.g., I speak). In addition, unlike English, Hindi verbs mark gender (Jain, 2011). Overall, Hindi and English nouns and verbs share multiple linguistic features in common although the two language systems are different in other domains (e.g., phonology, syntactic order, etc.). Past studies on semantic convergence have focused on comparing two European languages which come in frequent contact with one another (Ameel et al. 2005, Aferink & Gullberg, 2014) or on two languages that are relatively dissimilar like Mandarin and English (Malt et al., 2015). The current study looks at two languages that have not been compared when examining semantic convergence and therefore would increase the understanding of how bilingual language systems experience convergence.

Research Questions and Hypotheses

1. Does the degree of semantic convergence differ for nouns and verbs in Hindi-English bilinguals?

   Hypothesis 1: In a word association task for nouns and verbs in each language, bilinguals will show significantly different word association patterns for verbs (i.e., less translation pairs) than for nouns. Differences in language features of nouns and verbs suggest that semantic convergence for verbs would be less extensive than that for nouns. Verbs are more relational, complex, and dependent on linguistic context in comparison to nouns, and there is evidence that there is more semantic overlap for nouns across languages in comparison to verbs

(Bultena et al., 2013). In addition, there is some evidence that nouns have stronger cross-linguistic mappings compared to verbs (Van Hell & De Groot, 1998; Faroqi-Shah & Milman, 2015). Given the greater semantic overlap and stronger cross-linguistic mappings for nouns compared to verbs, it would be expected that nouns have greater opportunity for semantic convergence via the *cross-language interference hypothesis* and the *retrieval induced reconsolidation hypothesis.* For nouns, due to increased cross-linguistic mappings, there is more opportunity change in a bilingual's L1 via retrieval induced consolidation, because when a bilingual speaker accesses an L2 noun entry, the corresponding L1 analog is reactivated in addition to other related cross-linguistic lemmas (via the *cross-language interference hypothesis*).

Hypothesis 2: Alternately, given that verbs have less cross-language overlap (Van Hell & De Groot, 1998) and are more susceptible to word class ambiguity (Bultena et al., 2013), their semantic representations may be more malleable because of weaker links between lexical referents and semantic representations, showing greater semantic convergence for verbs relative to nouns (via the *weaker links hypothesis*). There is some evidence that verbs experience less cross-language activation due to less semantic overlap and that verb processing is susceptible to within-language overlap indicating that verbs are less fixed in the language system compared to nouns (Van Hell & De Groot, 1998; Bultena et al., 2013), and therefore, it is possible that verbs have overall weaker mappings to referents compared to nouns. If this is the case, then verbs would be more

susceptible to change compared to nouns and would show a greater degree of semantic convergence.

2. Does the degree of semantic convergence differ by age (when controlling for years of bilingual exposure)?

   Hypothesis 1: If healthy younger and older adult bilinguals are given a word association task, older speakers will demonstrate more semantic convergence for both nouns and verbs than adult populations. Over the course of development, bilingual children demonstrate increasing convergence in naming patterns over time as their cross-language lexical network strengthens and becomes more elaborate, which causes cross-activation to reshape their language system (Storms, Ameel, & Malt, 2015). If years of experience in a bilingual system leads to increased convergence over time and there is no upper limit to the degree of convergence that can occur, then older bilinguals would have more years of experience and therefore more convergence across their language system compared to younger adult bilinguals.

   Hypothesis 2: Given that healthy older monolinguals had similar performance on semantic decision tasks despite differences in neurological activation patterns (Lacombe et al., 2012), if healthy older and younger adult bilinguals are given a word association task, older adult populations will demonstrate no difference in semantic convergence for both nouns and verbs than younger adult populations.

Method

Design Overview

To determine the degree of semantic convergence in both research questions, younger (ages 18-35) and older adult bilingual groups (ages 60+) were given a word association task using verb and noun stimuli. In response to a presentation of a set of verb or noun stimuli presented auditorily, participants were asked to generate as many words associated with as possible within the span of 40 seconds in both languages over the course of two separate sessions. The generated words for verb and noun stimuli were compared in each language to determine to what extent the first four generated words in each language were translation pairs. Only the first four words were compared for translation pairs in order to account for the fact that participants may generate responses later within the 40 seconds in response to other responses as opposed to the original stimulus. The independent variables constituted word class (noun and verb) and participant age group (young and old), and the dependent variable was the number of generated translation pairs as a measure of semantic convergence.

Participants

Thirty-one Hindi-English bilinguals were contacted via email and via phone and screened for language proficiency. Among this initial group, twenty-seven of them met the criteria for proficiency (as outlined in the section below). Seventeen highly-proficient younger adult bilinguals (9 females, 8 males; mean age = 24.5, SD = 3.0; mean years of education = 17.1, SD = 1.3; mean age of first English exposure = 4.0 , SD = 2.8; mean age of first Hindi exposure = 2.5, SD = 2.7) and ten highly-proficient older adult bilinguals (7 females, 3 males; mean age = 67.8, SD =6.0; mean years of education =17.9, SD = 2.1; mean age of first English exposure = 6.7, SD = 3.8; mean age of first Hindi exposure =

2.2, SD = 3.5) were recruited. The groups did not differ in years of education ($t(25) = 1.28$, $p > 0.05$) and age of exposure to English ($t(25) = 2.05$, $p > 0.05$) and Hindi ($t(25) = 0.28$, $p > 0.05$). Given the multi-lingual culture of India, not all participants identified Hindi as their native language. In the younger age group, eight participants identified Hindi as their native language, and in the older age group, six participants identified Hindi as their native language. All participants were exposed to Hindi and English before the age of 12 years. Based on self-report, participants were excluded if they had a positive history of neurodevelopmental conditions.

Language proficiency screening and testing

This study recruited highly-proficient, balanced bilingual speakers of Hindi and English. Language proficiency was determined by performance on lexical decision tasks in both English and Hindi and object naming performance in both languages. The lexical decision task in English was conducted online through the Lexical Test for Advanced Learners of English (www.lextale.com). LexTale is a lexical decision task that tests vocabulary knowledge for medium to highly proficient speakers of English as a second language, and it takes less than 4 minutes to do (Lemhöfer & Broersma, 2012). All but one of the qualified participants scored above 70% (mean = 88%, SD = 0.09). The lexical decision task in Hindi was conducted in person and was modeled on the process outlined in the LexTale process by Lemhöfer & Broersma (2012) (Singh, Wang, & Faroqi-Shah, 2017). The percentage of correct responses (% correct) was calculated as: ((number of words correct/38*100) + (number of nonwords correct/32*100)) / 2. The qualified participants all scored above 70% (mean = 89%, SD = 0.06). Participants also completed

the object naming sections of the *Bilingual Aphasia Test* (BAT) (Paradis & Libben, 1987). All participants scored above 80% on the Hindi and English sections of the *Bilingual Aphasia Test* (English mean = 100%, SD = 0; Hindi mean = 91%, SD = 0.11). For English BAT performance, there was no difference in performance between the two age groups as every participant scored 100%. There were no statistical differences in the Hindi BAT performance between the older and younger adult participants ($t(27)= 1.68$, $p> 0.05$). In addition, older participants were administered the MOCA cognitive screening test to determine normal cognitive status. All participants scored above the criterion threshold for normal, which is a score of 26 out of 30 maximum points.

In addition, language dominance rating was obtained on the testing day from Bilingual Language Profile, which is a self-report instrument for assessing language dominance (Birdsong, Gertken, & Amengual, 2012). The range of possible scores for the language dominance index was -218 to 218, with the more extreme scores indicating higher dominance in any one language. A score of zero indicated equal language balance. The mean language dominance index for the younger adult bilingual participants was -5.98 (SD = 32.8), which was in the middle quartile (25% - 75%), and the mean language dominance index for the older adult bilingual participants was -7.80 (SD = 42.5), which was also in the middle quartile. Based on the language dominance scores, Hindi was reported to be more frequently used than English and was reported to be the more dominant language, although both languages were rated quite highly proficient. At the time of the study, all bilingual participants were currently residing in the United States for at least 6 months prior to the date of testing.

Stimuli and Procedures

Stimuli

Two sets of 28-word stimuli for nouns and verbs and one set of 13 words for adjectives were used for this study. The noun and verb stimuli were used for grammatical class comparison, and the adjective stimuli constituted filler stimuli in order to prevent response bias of participants towards nouns and verbs (Van Hell & DeGroot, 1998). The three sets of stimuli were constructed first in English and then translated into Hindi using the Oxford Hindi-English Dictionary (Sahai & Verma, 2010). English noun and verb stimuli were selected according to frequency (i.e., medium to high frequency) using the frequency values found in SUBTLEX word-frequency corpus (Brysbaert & New, 2009). Words were considered to be medium to high frequency if they had a frequency value equal to or greater than 30 Wmillion (frequency of the word per million words) according to the SUBLTEX word-frequency corpus (*nouns*: mean = 237.5, SD = 207.4, range = 41 to 866 Wmillion; *verbs*: mean = 298.3, SD = 306.2, range = 30 to 1168 Wmillion; $t(52) = 0.86$, $p > 0.05$) (Brysbaert & New, 2009). The noun and verb word lists consisted of concrete, imageable concepts to control for abstractness as a possible confounding factor in determining convergence. Concrete, imageable concepts were determined according to the set of imageability ratings compiled by the Center for Reading Research (Brysbaert, Warriner, & Kuperman, 2014). Given that frequency ratings were not available for Hindi, concreteness and familiarity of the stimuli in Hindi were then confirmed by surveying participants after they had completed the two sessions. Participants were asked to rate the concreteness of the stimuli used for testing on a 5-point scale similar to the procedures outlined in Brysbaert, Warriner, and Kuperman (2014). To determine familiarity, the

participants were asked to rate the Hindi words (translated from English) they heard on a 5-point scale system to determine how frequently they have encountered that word in Hindi-speaking culture. Words whose familiarity ratings were below 3.0 or whose concreteness ratings scored an average of below 2.5 were excluded from analysis. Ultimately, 28 nouns, 26 verbs, and 13 filler adjectives were used in the final results of the study. For familiarity ratings for the final set of stimuli, nouns had a mean of 4.81 (SD = 0.16, range = 4.32-4.96) and verbs had a mean of 4.65 (SD = 0.20, range = 4.36-5). There was a statistically significant difference between the two sets ($t(52) = 3.09$, $p < 0.05$). For concreteness ratings, nouns had a mean of 4.21 (SD = 0.51, range = 2.92-4.8) and verbs had a mean of 2.92 (SD = 0.33, range = 2.52-3.76). There was a statistically significant difference between the two sets ($t(52) = 10.9$, $p < 0.05$).

Procedures

Bilingual participants were tested individually in a quiet room or space across two, approximately 2-hour long sessions with rest breaks between blocks. For the first session, the tasks were administered to the participants in the following sequence: language proficiency tasks (object naming and lexical decision), language dominance task (BLP questionnaire), MOCA screening (for older participants) to determine cognitive status, and language experimental task in Hindi or English (word generation). For the second session, the tasks were administered in the following sequence: language experimental task in English or Hindi (word generation) and post-session survey (ratings for concreteness, code-switching, and familiarity). Testing sessions were scheduled at

least three days apart to prevent familiarity effects with testing stimuli. The sequence of testing bilingual language (Hindi vs. English) was counterbalanced across participants.

During the word generation task, participants were presented the words auditorily. The word stimuli in Hindi were audiorecorded by a proficient, native Hindi speaker, and the English stimuli were orally presented in person by the experimenter who is a native English speaker. Participants were presented with five, randomized 14-word blocks of nouns, verbs, and adjectives with 2-minute breaks between blocks. Participants were instructed to listen to the stimulus and to generate as many associated words as possible within 40 seconds in the same language. They were instructed to provide 1-2 words responses and to avoid proper names if possible in order to facilitate comparison across two languages. Participants were administered five practice trials (with words that are not part of the actual study) to learn the procedure. The session was audiorecorded for later transcription and analysis.

Data Analysis

All responses to English and Hindi stimuli were recorded including cross-language intrusions. The first four intelligible words in the target language generated for each stimulus were compared to determine if there were translation pairs. Initial translation pairs were determined using a Hindi-English dictionary (Sahai & Verma, 2010). For example, in response to the word *blood/khoon*, participant 8 of the younger bilingual group generated *red, body, oxygen, white* as his first four responses in English and *rakt, laal, lahoo, shareer* as his first four responses in Hindi. Two translation pairs, *red/laal* and *body/shareer,* were determined using the Hindi-English dictionary. The

translation pairs were then verified using six highly-proficient Hindi English bilinguals who were not participants in the study. The six raters (3 males, 3 females, mean age= 51.3 years, SD = 9.5; mean years of education = 20.2 years, SD = 4.1; mean average age of exposure to Hindi = 0.33 years, SD = 0.81; mean average age of exposure to English = 3.3 years, SD = 2.07) were asked to complete an online survey where the Hindi words of the potential translation pairs were presented. They were then asked to generate 1-3 English translations for each word under a time constraint of 20 seconds per word. Generated translations were then used to verify translation pairs of participants. Translation pairs were considered a match if at least three raters generated the corresponding English word in their translations. The number of translation pairs were analyzed using a linear mixed model analysis (Baayen, Davidson & Bates, 2008) with grammatical class (noun, verb) and age (young, older) as independent/fixed factors and participants and items as random factors. The findings were reported as a ratio of the number of translation pairs over the number of verb/noun stimuli (i.e., [total number of translation pairs for verb stimuli/28] for verbs; [total number of translation pairs for noun stimuli/30] for nouns) for each participant. For example, for participant 1 in the older participant group had 14 translation pairs across 28 nouns, resulting in a ratio of 0.46 for nouns. Adjectives were not included in the analysis as they served solely as filler stimuli to ensure that responses were not biased to include either nouns or verbs.

In addition to number of translation pairs, the responses of older and younger participants were analyzed for number of total responses in English and in Hindi and for the number of language intrusions of English words in the Hindi response task. All measures were analyzed using a linear mixed model analysis (Baayen, Davidson & Bates,

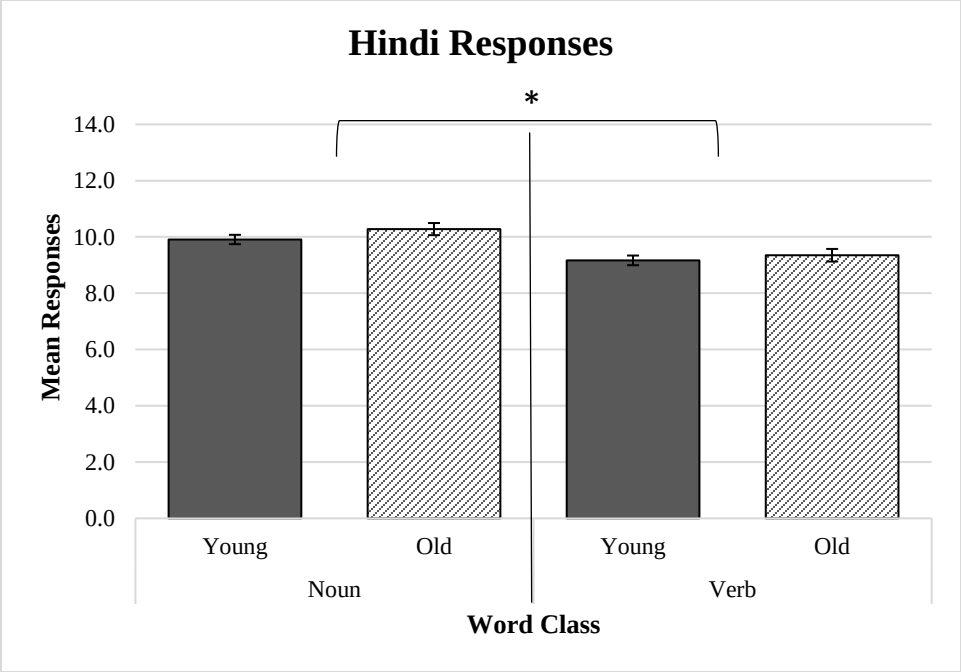
2008) with grammatical class (noun, verb) and age (young, older) as independent/fixed factors and participants and items as random factors..

Results

Descriptive information

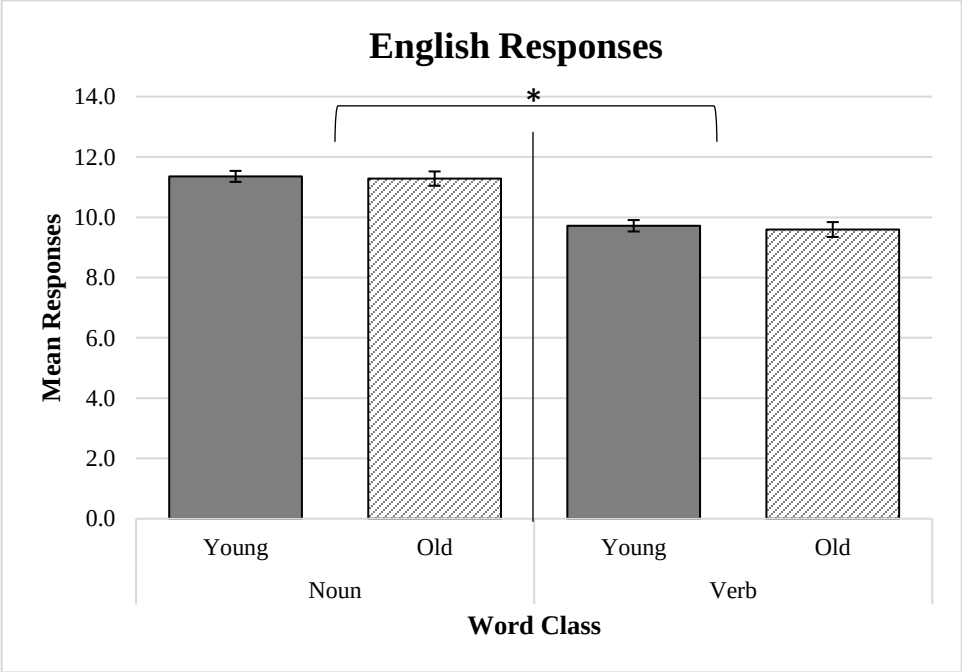
The number of Hindi and English responses by each group (young, old) for each word category (noun, verb) are illustrated in Figures 1 and 2. As evident from Figures 1 and 2 and Table 1, participants produced fewer word associations in response to verbs compared to nouns in both languages (Hindi responses: $\beta = 0.928$, $|t| = 2.981$, $SE = 0.311$, $p < 0.05$; English responses: $\beta = 1.68$, $|t| = 4.930$, $SE = 0.342$, $p < 0.05$), and there were no differences across age groups (Hindi responses: $\beta = -0.182$, $|t| = -0.646$, $SE = 0.282$, $p > 0.05$; English responses: $\beta = 0.124$, $|t| = 0.402$, $SE = 0.311$, $p > 0.05$).

Figure 1. Mean number of Hindi Responses. Error bars represent standard error of the mean.



* $p < 0.05$

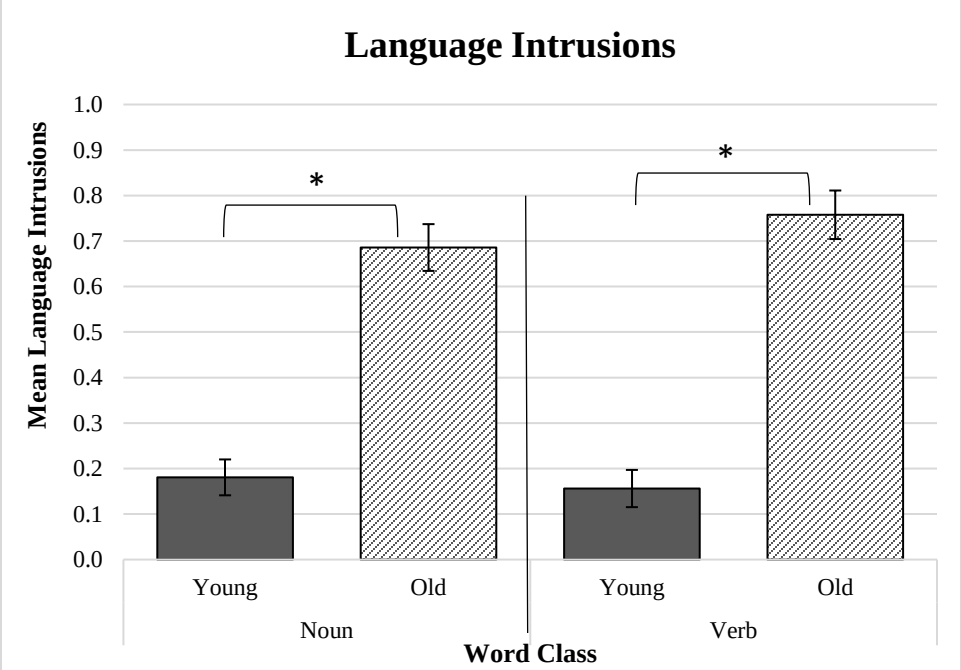
Figure 2. Mean number of English responses. Error bars represent standard error of the mean.



* $p < 0.05$

In addition, the number of language intrusions by each group and word class is outlined in Figure 3. Older adults produced more language intrusions compared to younger adults ($\beta = -0.601$, $|t| = -8.953$, $SE = 0.067$, $p < 0.05$) although the number of language intrusions did not differ by word category ($\beta = 0.168$, $|t| = -0.972$, $SE = 0.014$, $p > 0.05$).

Figure 3. Mean number of language intrusions in the word association task, generated over 40 seconds. Error bars represent standard error of the mean.



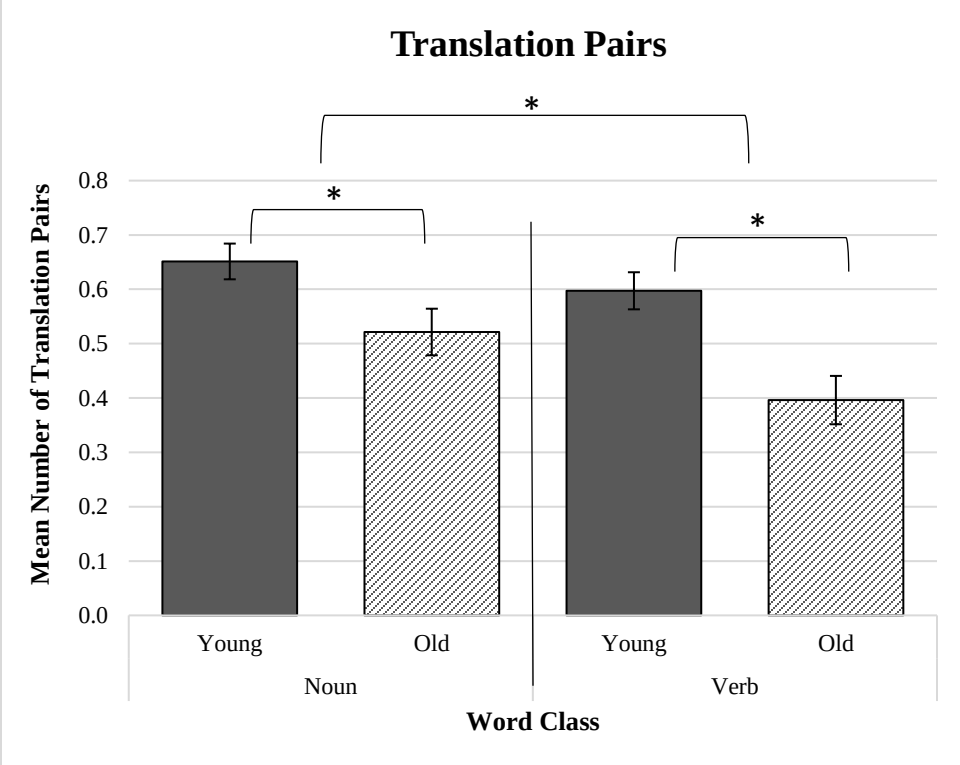
* $p < 0.05$

Research Questions

The first research question examined whether nouns or verbs had more translation pairs across bilingual participants as an indication of the degree of semantic convergence between Hindi and English language systems, and the second research question looked at

the degree of semantic convergence in older vs. younger adult bilinguals. The mean number of translation pairs by word class and by age group within the first four responses produced in each language is shown in Figure 4. The number of translation pairs was calculated as a proportion of the number of translation pairs over the number of verb/noun stimuli (i.e., [number of translation pairs/26] for verbs; [number of translation pairs/28] for nouns).

Figure 4. The mean number of translation pairs within the first four generated words. Error bars represent standard error of the mean.



* $p < 0.05$

Statistical analyses were conducted by linear mixed effects (LME) model (Baayen, Davidson, & Bates, 2008) in SPSS (IBM Corp, version 24.0) with age group (old and

young), word class (noun and verb), and an interaction term as fixed factors. The results of the statistical comparisons of age and word class categories for number of translations pairs, English responses, Hindi responses, and language intrusions is found in Table 1.

Table 1. Statistical comparisons between age and word class categories.

Group Comparison	Translation Pairs	English Responses	Hindi Responses	Language Intrusions
2 (age group: old, young) x 2 (word category: verb, nouns)	**Main effect of age group:** β(SE) = 0.201(0.056)* |t| = 3.587 **Main effect of word category:** β(SE) = 0.125(0.061)* |t| = 2.027 **Interaction:** β(SE) = -0.071(0.078) |t| = -0.916	**Main effect of age group:** β(SE) = 0.124(0.311) |t| = 0.402 **Main effect of word category:** β(SE) = 1.68(.342)* |t| = 4.930 **Interaction:** β(SE) = -0.052(0.432) |t| = -0.120	**Main effect of age group:** β(SE) = -0.182(0.282) |t| = -0.646 **Main effect of word category:** β(SE) = 0.928(0.311)* |t| = 2.981 **Interaction:** β(SE) = -0.186(0.393) |t| = -0.475	**Main effect of age group:** β(SE)= -0.601(0.067)* |t| = -8.953 **Main effect of word category:** β(SE)= 0.168(0.014) |t| = -0.972 **Interaction:** β(SE) = 0.097(0.093) |t| = 1.035

(* =p<0.05)

The results revealed a main effect of word class: older and younger bilingual participants had more translation pairs for nouns than for verbs ($\beta = 0.125$, $|t| = 2.027$, $SE = 0.061$, $p < 0.05$). There was also a main effect of age: younger adult bilingual participants had a greater number of translation pairs within the first four responses compared to older adult bilingual participants ($\beta = 0.201$, $|t| = 3.587$, $SE = 0.056$, $p < 0.05$). There was no significant interaction between word class and age (Table 1).

Discussion

This study addressed to what extent the degree of semantic convergence differs with word class (nouns vs. verbs) and with age (young vs. old). Semantic convergence was measured using a modified method similar to that of Van Hell and De Groot (1998), which involved identifying translation pairs across languages using a word association task. A word association task serves to map part of the network of a semantic representation, and the number of translation pairs indicates how much overlap exists in the semantic networks of a single representation in each language. The overlap between languages is an indication of the degree of semantic convergence in a bilingual language system. To our knowledge, this is the only study to examine semantic convergence by grammatical category and with aging.

Semantic convergence by word class

The first research question examined whether there was a difference in the degree of semantic convergence for nouns compared to verbs in Hindi-English adult speakers. This study found that both older and younger Hindi-English participants had more translation pairs for nouns compared to verbs and therefore had more semantic convergence for nouns. This result is consistent with the findings of Van Hell and De Groot (1998), who found that nouns had more translation pairs compared to verbs in their study examining bilingual semantic memory. However, their study did not examine translation pairs in the context of semantic convergence.

It was suggested by Van Hell and De Groot (1998) that nouns have greater cross-language semantic overlap and more dense semantic representations compared to verbs

possibly because verbs have a greater range of meaning and are relatively more dependent on linguistic context. If we assume that a word association task serves as a measure of the semantic network for a representation, then the number of responses can serve as a measure of the density of a semantic network for a word. The idea that semantic representations are denser for nouns compared to verbs is supported by the present study's findings in which nouns as a word class elicited a greater number of responses compared to verbs in both languages (Figures 1 and 2). On average, participants produced approximately one and a half more word associations in English for nouns (mean = 11.3, SD = 0.15) compared to verbs (mean = 9.7, SD = 0.16) and one more word association in Hindi for nouns (mean = 10.1, SD = 0.14) compared to verbs (mean = 9.3, SD = 0.14) in the 40-second response window that was provided.

Examples of responses in English to noun and verb stimuli can be found in Table 2. The example responses show more responses for the noun stimulus for both the older and younger participant compared to the verb. For both the older participant and younger participant, the noun stimulus elicited two more responses (older: 8 responses for noun stimulus, 6 responses for verb stimulus; younger: 13 responses for noun stimulus, 11 responses for verb stimulus). The difference between the numbers of responses for verbs and nouns in these two examples is typical of the overall responses for verbs and nouns.

Table 2. Example noun and verb responses from one younger participant and one older participant

Participant	**Responses to verb stimulus: *sit***	**Responses to noun stimulus: *blood***
YN-605	tired, chair, rest, legs, back, walk, table, furniture, rest, relax, talk	family, relative, hemoglobin, heart, body, friend, cut, first aid, Band-Aid, donation, blood type, blood bank
AN-600	lazy, work situation, limitation, cramps, tiredness, rest	clot, aspirin, heart, surgery, wound, bleeding, life necessity

There are two potential confounding factors that may have influenced the number of translation pairs by word class: differences in concreteness and familiarity as rated by the participants themselves. A comparison of nouns and verbs for concreteness ($t(52) = 10.9$, $p < 0.05$) and familiarity ($t(52) = 3.09$, $p < 0.05$) showed statistically significant differences between the stimuli sets. It has been shown that concrete words elicit more translation pairs in word association tasks compared to abstract words (Van Hell & De Groot, 1998). However, in the current study, there were no correlations found between concreteness and number of translation pairs ($r = 0.14$, $p > 0.05$) or between familiarity and number of translation pairs ($r = 0.09$, $p > 0.05$). Based on the correlation results, it is unlikely that differences in concreteness and familiarity between the noun and verb stimuli impacted the number of translation pairs, and it provides further evidence that differences in semantic convergence for nouns and verbs are correlated with inherent word class differences.

While current theories of semantic convergence account for the occurrence of semantic convergence in bilinguals relative to their monolingual counterparts via the

retrieval induced reconsolidation hypothesis, the underlying mechanisms that account for noun-verb differences in semantic convergence are not clear (Ameel et al. 2005; Aferink & Gullberg, 2014). There are a few considerations that may help explain the increased semantic convergence for nouns compared to verbs. It is possible that verbs show less convergence due to overall less cross-linguistic activation. A study by Gentner (1981) showed that in a double translation task, similar to that of Van Hell and De Groot (1998), bilinguals had more back translations for nouns compared to verbs, indicating weaker cross-linguistic mappings for verbs compared to nouns. There is some evidence that verbs have less dense semantic representations compared to nouns (Van Hell & De Groot, 1998). In addition, it is possible that verbs have weaker semantic representations and are more vulnerable compared to nouns as shown by worse performance on verb production tasks compared to nouns in bilinguals with aphasia (Kambanaros, 2010; Faroqi-Shah & Waked, 2010). Weaker cross-linguistic mappings and less density and more vulnerability in semantic representations could lead to decreased cross-linguistic activation and cross-language interference of verbs and less opportunity for semantic convergence compared to nouns. In addition, decreased cross-linguistic interference and activation of verbs is consistent with studies that found smaller verb deficits in language production tasks (Faroqi-Shah & Milman, 2015).

Van Hell and De Groot (1998) suggest that verbs have a greater range of meaning and are more dependent on linguistic context compared to nouns. The current study relied on production of isolated, single words in response to single word stimuli. It is possible that verb networks experience less activation in single word tasks like this study because they rely on relational information to nouns and linguistic context for meaning. Verb stimuli

may have elicited fewer translation pairs compared to nouns due to lack of context clues for meaning. On the other hand, concrete nouns consist of mappings between physical entities and their corresponding label which does not require additional linguistic context to deliver meaning (Bird, Howard, & Franklin, 2000; Faroqi-Shah & Waked, 2010). Therefore, it is possible that verb networks across a bilingual's languages rely on other semantic representations (i.e., nouns) for meaning within a specific language, and therefore are less vulnerable to semantic convergence compared to nouns. Furthermore, verbs are highly related to syntactic structures, and it should be noted that English and Hindi differ syntactic structure and word order form. In English, utterances typically use subject-verb-object word order whereas in Hindi, subject-object-verb order is typically used (Gertner, Fisher, & Eisengart, 2006; Jain, 2011). Given the relative linguistic nature of verbs, and the cross-linguistic difference in word order for verbs, verb to verb mappings in English and Hindi may be weaker overall compared to nouns, which are found in sentence initial position in both languages. Weaker cross-linguistic mappings for verbs are consistent with the findings of the study and may explain why there is less opportunity for cross-linguistic activation and semantic convergence.

The findings of the current study are not inconsistent with the *retrieval induced reconsolidation hypothesis* as outlined by Ameel and colleagues (Ameel et al., 2005; 2007). However, retrieval induced reconsolidation does not fully explain the difference in semantic convergence between word classes. The results of the current study show that nouns have a greater degree of semantic convergence compared to verbs, which is more consistent with the application of the *cross-language interference hypothesis* and the *retrieval induced reconsolidation hypothesis* to the idea of semantic convergence. The

cross-language interference hypothesis outlined by Green (1998) suggests that bilingual speakers perform language production tasks accurately by inhibiting associated, within-language and cross-language lemmas. It is possible that nouns experience more cross-language activation of lemmas due to greater cross-language semantic overlap as outlined in the study by Van Hell and De Groot (1998). This increased cross-language activation of lemmas for nouns may provide more opportunities for both L1 and L2 analogs to be activated and changed via retrieval induced reconsolidation as outlined by Ameel and colleagues (Ameel et al., 2009).

Ameel and colleagues attribute the *retrieval induced reconsolidation hypothesis* in conjunction with the *weaker links hypothesis* outlined by Gollan et al. (2008) as a possible mechanism for semantic convergence. The *weaker links hypothesis* suggests that bilingual language systems are more vulnerable to change compared to monolinguals because the bilingual language system has weaker mappings onto referents in each language (Gollan et al., 2008). According to Ameel et al. (2009), bilinguals' weaker mappings of lexical representations makes the language system of bilinguals more vulnerable to change via the retrieval induced reconsolidation hypothesis. If the *weaker links hypothesis* was applied to explain the difference in convergence between nouns and verbs, it would be expected that verbs would show a greater degree of convergence because they are expected to have weaker mappings to referents compared to nouns, which is inconsistent with the current study's findings that nouns have greater semantic convergence.

It should be noted that the *retrieval induced reconsolidation hypothesis, cross-language interference hypothesis,* and the *weaker links hypothesis* explains semantic

convergence through lexical phonological activation mechanisms. Ameel and colleagues, citing Wolff and Ventura (2009), suggest that lexical mechanisms (i.e., *retrieval induced reconsolidation hypothesis* and *weaker links hypothesis*) activate the underlying semantic representations and thus make bilingual semantic systems more labile and susceptible to change (Ameel et al., 2009). However, neither the *weaker links hypothesis* nor the *cross-language interference hypothesis* fully accounts for the difference in semantic convergence by word class. Current theories of semantic convergence and bilingual semantic systems may need to be adjusted to account for word class differences.

Semantic convergence by age

The results show that there is a main effect for age on the number of translation pairs, where younger adult bilingual participants had a greater number of translation pairs within the first four responses compared to older adult bilingual participants. The findings indicated that there is a greater degree of semantic convergence in younger adults compared to older adult bilinguals. These results are somewhat surprising, since it was expected that with increased bilingual experience over time, there would be greater semantic convergence compared to younger adults. Although there are no studies known to the author that explore aging and semantic convergence, there has been a single study examining convergence in naming patterns in bilingual children over the course of childhood development (Storms et al., 2015). In their study, bilingual children showed increasing convergence in naming patterns in their two languages from ages 5 to 14, with the most convergence at age 14. These findings suggest that increased experience with the two languages led to more cross-activation of words in both languages, and thus led

to more convergence over time (Storms et al., 2015). Based on the results of this study, it was expected that since older adult participants have more experience with the bilingual language system compared to younger adult participants, older participants would show more convergence not less than younger ones. However, the results show that there must be another process related to aging that accounts for less convergence in older participants.

Compared to healthy aging in monolingual speakers, there are relatively few studies that examine healthy aging in bilinguals. However, the difference in semantic convergence between younger and older bilingual adults may be explained by an overall decline in language processing and/or change in language processing patterns as bilinguals age normally. Studies on healthy aging in monolinguals show that older adults have increased difficulty with lexical retrieval and are more likely to experience tip-of-the tongue moments compared to younger adults (Kavé & Knafo-Naom, 2015; Shafto et al., 2010). These lexical retrieval difficulties have been noted to occur for both verbs and nouns (Mackay, Connor, Albert, & Obler, 2002). Healthy older adults not only have decrease performance on lexical retrieval tasks, but there is also evidence that the neural correlates for lexical retrieval change with aging to recruit additional areas in the right hemisphere (Cotelli, Manenti, Brambilla, Zanetti, & Miniussi, 2012).

There is some evidence that older bilinguals have different lexical processing patterns relative to younger bilinguals potentially due to reduced executive control. Older adult bilinguals have shown decreased efficiency in inhibiting competing lexical items (i.e., cross-linguistic interference) (Zied et al., 2004). In addition, executive control in older but not younger bilinguals on verbal fluency tasks correlated with the number of

cross-language intrusion errors, indicating that language performance may be impacted by cognitive aging processes (Gollan et al., 2011). Alternatively, Burke and Shafto (2004) have suggested that lexical retrieval difficulties in older adults in general may be due to weakness in the connections between the semantic system and the phonological/orthographic systems (Burke & Shafto, 2004).

In the current study, language intrusion errors were analyzed by age group and word class to determine if decrease in executive control could explain differences in performance and degree of semantic convergence. In this study, it was found that there was a main effect for age on the number of intrusion errors, and older participants overall had more language intrusions from their L2 into their L1 compared to younger adults. The underlying cause for greater language intrusions among older Hindi-English bilingual participants could plausibly be decreased executive control in older bilinguals and/or weaker connections between semantic and phonological systems in older adults as both of these phenomena may result in increased cross-language interference (Gollan et al., 2011; Burke & Shafto, 2004). The findings in the current study are consistent with the findings of Gollan et al. (2011) in which younger and older bilingual adults were given a verbal fluency task. The verbal fluency task in the study by Gollan et al. (2011) and the word association task in the current study both rely on strategic searching through the mental lexicon. In their study, it was found that older bilinguals had more unintentional cross-language intrusion errors compared to their younger bilingual counterparts, and cross-language intrusion errors in older bilinguals were associated with higher error rates in a flanker-type task.

One way to examine if the smaller semantic convergence in older adults is due to language intrusions is to correlate the number of translation pairs with the number of intrusion errors. In this current study, the correlation between the number of language intrusions and translation pairs were run for older participant responses to noun stimuli and verb stimuli and for younger participant responses to noun stimuli and verb stimuli (i.e., for four groups: older-noun, older-verb, younger-noun, younger-verb). There was a correlation between the number of language intrusions and the number of translation pairs for older participants in response to noun stimuli ($r_s = -0.151$, $p < 0.05$) but not for the other groups including older participants responding to verb stimuli. This offers some evidence that decreased inhibitory control and/or weaker connections between semantic and lexical systems, at least for nouns. This is consistent with the hypothesis that nouns experience greater cross-linguistic activation compared to verbs (Faroqi-Shah & Milman, 2015; Van Hell & De Groot, 1998), which supports greater opportunities for noun convergence via the *retrieval induced reconsolidation hypothesis*. However, if decreased inhibitory control and weakened connections were the underlying reason for difference in convergence by age, we would expect that there would be a correlation between number of language intrusions for older bilinguals for both nouns and verbs.

Another explanation for the difference of semantic convergence by age group could be language attrition, where L2 language intrusions into L1 responses serves as a measurement of language attrition. Given that older participants experienced more language intrusions and less semantic convergence compared to younger participants, it is possible that overall language attrition makes the L1 less activated during lexical production tasks and therefore less susceptible to semantic convergence via the *retrieval*

induced reconsolidation hypothesis. Difficulties with lexical retrieval and lexical processing have been documented in language attrition studies whereby bilingual speakers incorporate lexical items or semantic elements from their L2 in their L1 usage (Goral, Libben, Obler, Jarema, & Ohayon, 2008; Schmid, 2013). In one preliminary study, comparisons on lexical decision task performance between older and younger Hebrew-English bilinguals showed language attrition effects but not aging effects on lexical processing (Goral et al., 2008). However, it has been noted that lexical access difficulties attributed to language attrition may be due to extra-linguistic demands to produce and process words quickly rather than actual language attrition, i.e., loss of access to L1 elements (Schmid, 2013). In the current study, if language attrition it would have been expected that language intrusion errors would be correlated with corresponding L1 language proficiency in older adult participants. However, it was found that there no correlations between average number of language intrusion errors by participant and their corresponding Hindi BAT proficiency scores ($r_s = -0.010$, $p > 0.05$). In addition, there were no correlations found between the Bilingual Language Profile scores and average number of language intrusions for older adult participants. Although language measures in the current study (i.e., BLP scores and Hindi proficiency as measured by BAT performance) do not correlate with language intrusions, it is possible that other language measures and/or more comprehensive language measures in Hindi and English may reveal differences in language processing among older bilingual speakers that correlate with semantic convergence. In addition, older participants may have had more language intrusions from their L2 (English) due to the combined impact of

the time pressure to generate words within 40 seconds along with difficulties with lexical retrieval related to healthy aging.

Given that the current study limited analysis of translation pairs to the first four responses, it is possible that older adults may have generated more translation pairs if all responses were analyzed. It is possible that lexical retrieval difficulties associated with normal aging prevented ease of access to semantic representations, and older adults required more attempts to search their mental lexicon to retrieve semantically related words. If this is the case, then the difference in semantic convergence as measured by the current study may be explained by lexical retrieval issues rather than changing patterns in semantic convergence.

Current theories of aging focus primarily on lexical retrieval and processing patterns in aging bilinguals and do not adequately address how bilingual semantic systems change over time nor do they fully explain why aging bilinguals experience less semantic convergence compared to younger bilinguals. It is difficult to tease apart the roles that lexical retrieval difficulties, language attrition, and decrease in inhibitory control may play in semantic convergence for aging bilingual speakers. It does not appear that any one theory or phenomenon of aging and language accounts for semantic convergence, but it is possible that there are multiple factors that contribute to decreased semantic convergence across the lifespan. Further research is needed to investigate the underlying mechanisms for aging and semantic convergence.

Conclusions and Future Research Directions

The findings of this study built on the limited literature of semantic convergence (Aferink & Gullberg, 2014; Fredsted, 2008; Ameel et al, 2005; Ameel et al., 2009) and extended the study of semantic convergence to word class and healthy aging in bilingual populations with a previously unexplored bilingual group (Hindi-English bilinguals). The study found that nouns showed more semantic convergence compared to verbs. This finding is consistent with studies that suggest nouns have more cross-language semantic overlap compared to verbs (Van Hell & De Groot, 1998, Bultena et al., 2013). Given that nouns may have more cross-language overlap compared to verbs, the findings provide the some evidence for a combination of retrieval induced reconsolidation and cross-language interference mechanisms driving semantic convergence (Ameel et al., 2009; Green, 1998).

In addition, the findings of this study showed that younger bilingual adults had more semantic convergence compared to older bilingual adults. While healthy bilingual aging is not fully explored, the current literature suggests that older bilinguals are susceptible to similar differences as older monolingual counterparts, namely lexical retrieval difficulties (Kavé & Knafo-Naom, 2015; Shafto et al., 2010; Gollan et al., 2011). The underlying factors for differences in semantic convergence by age group are not fully understood, but it is possible that lexical retrieval difficulties played a role in accessing semantic representations within first four attempts to generate word associations.

The current study had a few areas for improvement. First, the design of the current study did not allow for a nuanced examination of difference in performance in older and younger adult participants. The designed study used a lexical production task to

measure semantic convergence which could me more difficult for aging adults. Removing time constraints and/or considering more than the first four responses may help to account for any lexical retrieval difficulties experienced by older adults. Second, the study did not fully examine the nuances of translatability and the impact of personal life experience on word generation. It is has been found that translation choices of single words in a decontextualized setting may be reflective of personal experience (Prior, Wintner, MacWhinney, & Lavie, 2011). This may have had an impact on translation decisions by the six-person rater panel. In addition, it is possible that responses to single words in English or Hindi may also be reflective of individual experiences that differed in English-speaking or Hindi-speaking contexts.

The findings of the present study warrant further study into semantic convergence of word class and age with other bilingual populations, particularly with bilingual populations for whom there is less code-switching and cross-language use compared to Hindi and English. In addition, further research is necessary to tease apart the influences and mechanisms of aging, particularly lexical retrieval difficulties, and their impact on semantic convergence. In addition, further research is needed into the underlying mechanisms of semantic convergence more generally. Even though the current study supported a combination of retrieval induced reconsolidation and cross-language interference mechanisms, these findings may be informed and better understood in the context of greater body of research.

Appendix A – Task Instructions

"I'm looking at word associations with words in English and Hindi. I'm going to say a word in (*Hindi/English*). In response, I want you to list as many words as you can that come to mind when you hear that word. So for one example, if the word is shirt, I might say button, skirt, clothing, wear, etc. For a second example, if the word is run, I might say jog, legs, runner, etc. When I say a word, please list as many words that you can think of within 40 seconds. Please remember that responses should be only 1-2 words each, and please avoid proper names if possible. I will be keeping track of the time and will let you know when to stop. I will be recording your answers for later analysis."

Appendix B (a) – Noun Stimuli

English Word	Hindi Translation	SUBTLEX English frequency per million	Average Familiarity Rating for Hindi
animal	जानवर	45	4.92
blood	खून	186	4.76
boy	लड़का	224	4.88
brain	दिमाग	77	4.72
car	गाड़ी	483	4.80
child	बच्चा	157	4.92
city	शहर	169	4.72
clock	घड़ी	58	4.88
daughter	बेटी	354	4.92
door	दरवाजा	292	4.84
hair	बाल	153	4.80

hat	टोपी	64	4.56
house	घर	514	4.64
king	राजा	129	4.36
man	आदमी	372	4.32
money	पैसा	640	4.40
morning	सुबह	439	4.84
mouth	मुंह	104	4.76
night	रात	866	4.96
office	दफ्तर	203	4.52
oil	तेल	41	4.84
story	कहानी	220	4.88
street	सड़क	148	4.76
tea	चाय	58	4.92
teeth	दांत	47	4.84
tree	पेड़	65	4.88
window	खिड़की	86	4.88
world	दुनिया	455	4.84

Appendix B (b) – Verb Stimuli

English Word	**Hindi Translation**	**SUBTLEX English frequency per million**	**Average Familiarity Rating for Hindi**
ask	पूछना	483	4.8
bring	लाना	327	4.56
carry	ले आना	66	4.44

catch	पकड़ना	136	4.64
climb	चढ़ना	30	4.52
cry	रोना	66	4.80
die	मरना	261	4.88
eat	खाना खाना	252	5.0
enter	प्रवेश करना	30	4.44
give	देना	1168	4.48
hang	लटकना	148	4.36
hide	छुपना	70	4.60
hit	मारना	275	4.44
jump	कूदना	70	4.36
listen	सूना	545	4.84
marry	शादी करना	104	4.84
open	खोलना	320	4.48
put	रकना	828	4.48
read	पढ़ना	241	4.88
shut	बंद करना	264	4.52
sit	बैठना	311	4.88
sleep	सोना	228	4.96
teach	सिखाना	73	4.72
thank	शुक्रिया अदा करना	1115	4.56
throw	फेंकना	129	4.64
walk	चलना	216	4.88

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